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Effects of Viscous Dissipation and Radiation on MHD Natural Convection in Oblique Porous Cavity with Constant Heat Flux

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Abstract. Effects of viscous dissipation and radiation on MHD natural convection in oblique porous cavity with constant heat flux is studied numerically in the present article. The right inclined wall is maintained at a constant cold temperature T_c and the left inclined wall has a constant heat flux q with length S, while the remainder of the left wall is adiabatic. The horizontal walls are assumed to be adiabatic. The governing equations are obtained by applying the Darcy model and Boussinesq approximations. COMSOL's finite element method is used to solve the non-dimensional governing equations together with specified boundary conditions. The governing parameters of this study are Rayleigh number ($Ra=10,100,200,250,500$ and 1000), Hartmann number ($0\le Ha\le 20$), inclination angle of the magnetic field ($0^\circ \le \omega \le \pi/2$), Radiation ($0\le R\le 15$), the heater flux length ($0.1\le H\le 1$) and inclination angle of the sloping wall ($-\pi/3\le \phi\le \pi/3$). The results are considered for various values of the governing parameters in terms of streamlines, isotherms and average Nusselt number. It is found that the intensity of the streamlines and the isotherm patterns decrease with an increment in Hartmann number. The overall heat transfer is significantly increased with the increment of the viscous dissipation and the radiation parameters.

AMS subject classifications: 65M06, 80A20, 76S05

Key words: Heat transfer, MHD natural convection, porous media, viscous dissipation, radiation.

1 Introduction

Natural convection inside closed cavities filled with porous medium has received consid-

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erable attention over the past few years and the importance of this issue back to the wide range applications in many industrial applications. Such applications have designing solar collectors, crystal growth, solar thermal receivers, packed sphere beds, geothermal energy systems, uncovered flat plate solar, migration of moisture etc. The investigation of natural convection in a porous medium with the influence of magnetic field has interest in many science, engineering, and technology fields. Details and more applications to understand this subject can be found in the excellent books (see [1–4]).

Most of the previous studies are considered the natural convection in square or rectangular cavities filled with porous media (see [5–13]). On the other hand, there are several studies, which involved the shape of the cavity is non-rectangular in practical engineering applications such as solar collectors or heat exchangers with different shaped duct constructions. [14] numerically studied the natural convection in an oblique cavities filled with a fluid-saturated porous medium by using finite difference method. The two inclined walls were maintained at a constant temperature and the horizontal walls were adiabatic. The results showed that the on the left wall the heat transfer rate increased and then decreased taking a minimum value near the top horizontal wall. [15] used the finite difference method to investigate the steady natural convection heat transfer in an inclined trapezoidal cavity filled with a fluid-saturated porous medium. They found that the average Nusselt number increased with an increment of Rayleigh number excepting for some inclination angle values. [16] numerically investigated the natural convection in a trapezoidal porous cavity by using finite element method. They concluded that the heat transfer rate was increased with increasing values of Rayleigh number or angle of inclination of the cavity walls. [17] theoretically and numerically studied the natural convective flow and heat transfer in an inclined trapezoidal cavity filled with a fluid-saturated porous medium. They found by using the finite difference method that the values of mean Nusselt number decreased with increasing of sidewall inclination angle and became almost equal to the values for a square cavity. Unlike the study of convective flow in a square or rectangular cavities problem, the study of convective flow in a non-rectangular geometry is difficult to determine due to the presence of sloping walls. In general, the mesh nodes do not tend to lie along the sloping walls and consequently, from a programming and computational point of view, significantly increasing the effort required for determining flow characteristic.

Recent problems included the effect of the magnetic field on natural convection in a porous medium due to its wide applications such as in the polymer industry and metallurgy as studied by [18]. They studied the effects of the magnetic field on natural convection in a rectangular cavity filled with a porous medium. They found that the heat transfer rate decreased with an increasing in the magnetic field. [19] numerically investigated the unsteady MHD natural convection in an inclined square cavity filled with a fluid-saturated porous medium and with internal heat generation. They concluded that an increasing in both of the magnetic field force and the inclination angle of the cavity led to the increment of the fluid temperature. [20] investigated the effect of an inclined magnetic field on unsteady natural convection in a square cavity filled with a fluid-saturated